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METHOD AND MEANS FOR PREVENTING HEATER CATHODE LEAKAGE IN A RADIO TUBE

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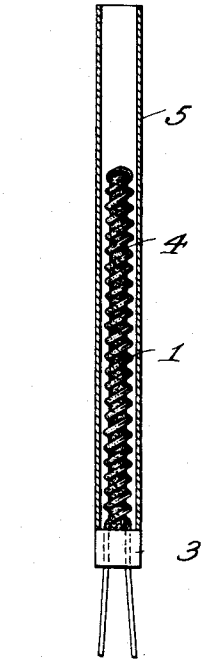


Fig. 1.

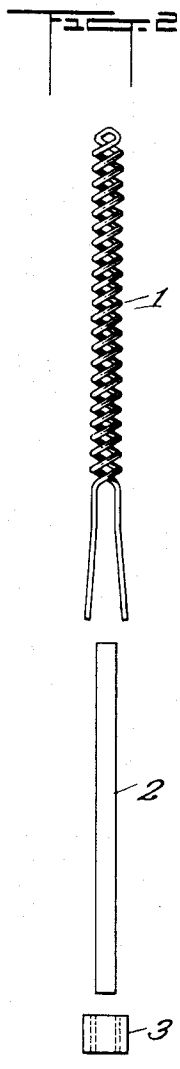


Fig. 2.

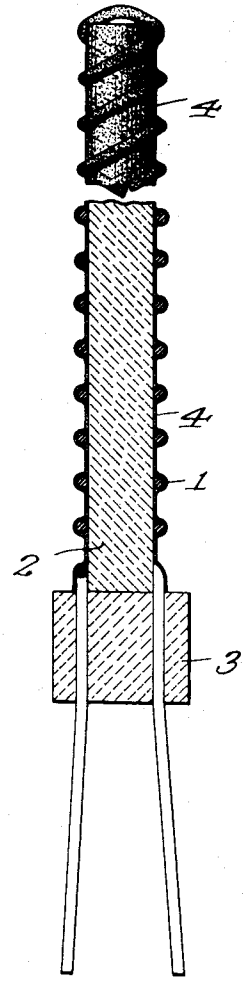


Fig. 3.

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METHOD AND MEANS FOR PREVENTING HEATER-CATHODE LEAKAGE IN A RADIO TUBE

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5 Claims. (Cl. 250—27.5)

In vacuum tubes a common source of electron emission is a coated cathode element. There are two forms of cathodes, one which is heated directly and the other heated indirectly. Frequently the indirectly heated cathode is an assembly or unit comprised of a core rod, a heater element, and a tubular sleeve, usually designated as the cathode sleeve. In order to produce electrons copiously, the cathode sleeve is coated with an electron emission material such as the oxides of the alkaline earth metals barium, strontium and calcium, either singularly, or mixed in various proportions. As these oxides (in order to emit electrons freely) must be heated to a temperature of approximately 850° C., considerable heat must be applied to the cathode sleeve in order to maintain the necessary temperature. This heat is generated by the heater element which is composed of a metal filament adapted to be connected to a source of electrical energy.

The heater, although generally spaced close to the cathode sleeve, must be electrically separate therefrom. This requires that the heater be completely insulated from the cathode sleeve, unless the sleeve is of sufficient diameter that the heater may be supported without danger of coming into contact with it. As the latter form of construction is not efficient because of losses inherent in wide spacing of the heater and cathode sleeve, it is almost the universal practice to have the heater closely spaced to the cathode sleeve.

It is customary to use a filament coiled in the form of a double helix for the heater element, and in order to prevent short circuiting of the turns thereof, a ceramic core or plug is employed. The close spacing between the cathode sleeve and the heater requires that the heater wire itself be coated with a material having good electrical insulating properties at the operating temperature, say 900° to 1800° C. depending on the tube in order to avoid heater-cathode leakage. For the purpose of this specification heater-cathode leakage may be defined as objectionable conduction between the heater coil and the cathode sleeve through the hot insulating coating material therebetween. In certain receiving set circuits leakage in excess of twenty-five microamperes is objectionable. Moreover, variation in this leakage produces noise.

The refractory materials used in the past for the construction of the heaters have been quite satisfactory when used in connection with the average circuit, but with the higher potential differences between heater and cathode existing in the modern circuits, these materials have been unsatisfactory with respect to their electrical leakage and accompanying noise. As an example, it may be mentioned that electrical leakage, existing between heater and cathode is directly responsible for producing disturbing noises in the loud speaker of a set using radio tubes having relatively high potential differences (as for instance, a bias of 50 to 100 volts) between heater and cathode, especially when such a tube is subjected to vibration, either mechanical or acoustic.

It is, therefore, an object of the invention to prevent heater-cathode leakage, more particularly in radio tubes having high potential differences between the heater and the cathode.

Another object is the provision of a coating material for the heater coil having good insulating properties at high temperatures.

Another object of the invention is the providing of a refractory composition which may be used for both the core rod and the insulating coating for the heater coil, without fear of any change in the physical properties of the composition being effected by diffusion thereof between these elements at high temperatures.

Further objects of the invention will manifest themselves as the description proceeds.

Referring to the accompanying drawing:

Fig. 1 is an elevation, partly in section, of a heater assembly for a cathode of the indirectly heated type;

Fig. 2 is a perspective of the several parts comprising the heater assembly; and

Fig. 3 is a greatly exaggerated view, partly in section, of the heater without the cathode sleeve.

As shown in the drawing, particularly Fig. 2 thereof, the construction of the heater assembly comprises a coil 1 of tungsten or the like, wound in the form of a double helix, with the ends thereof terminating in straight portions which serve as terminals for connecting the coil to a source of electrical energy. Inside of the coil 1 is inserted a core rod 2 of proper length and diameter so as to be frictionally retained in position and extend throughout the coiled portion of the heater element. The function of the core rod is to lend support to the coil, but primarily is to prevent the short circuiting of the turns thereof. When the filament for the heater is of larger diameter than five or six thousandths of an inch, it is well to insert over the ends of the filament a double hole plug 3 of refractory material in order to lock the ends of the filament. The assembled heater is inserted into a cathode sleeve 5, made of nickel and partly coated externally with

an oxide of an electron emission material such as mentioned above.

It will be noted that this type of heater must not only be insulated from the cathode sleeve, but must also have the turns of the heater wire insulated from each other. For satisfactory performance as heaters, the refractory insulation used in the construction thereof should, at temperatures of 1600°–2000° C. be highly refractory and somewhat porous, have a low coefficient of expansion, sufficient vitrification to produce the desired mechanical strength, and above all a minimum of electrical leakage.

In the past it has been customary to manufacture the core rods and plugs by the extrusion, and final baking in air or hydrogen at 1600° C. of an extrusion mixture made up of magnesium or aluminum oxide, together with a suitable fritting material such as silica and a paste carrier such as a solution of nitrocellulose. The spray mixture 4 used for coating the coil and core rod has been made heretofore of aluminum oxide, together with a suitable binding material such as silica and suspended in a solution of nitrocellulose. After spraying the complete assembly is baked in hydrogen at a temperature of 1600° C.

In an effort to prepare refractory compositions superior to those used in the past, I have discovered that pure beryllium oxide, when used as the basic constituent of the refractory mixture for the manufacture of the insulating parts of the heater, will prevent, or materially decrease, the electrical leakage, and thus prevent or materially decrease the noises due to such leakage. Also, the value of the oxide as an insulator materially increases as the percentage of other constituents decrease.

I have also discovered that the quality of the material as an insulator considerably increases when heated at a temperature of 1600° to 2000° C., for a substantial period, either in air, hydrogen, or vacuum, but preferably in vacuum.

I have further discovered that in order to maintain the definite composition of the refractory materials comprising the various insulating parts of the heater, it is desirable to have the compositions of the various insulating parts identical. In other words, the insulating parts should preferably be manufactured from the same refractory composition. I have found that if this is not the case, a transfer or diffusion of the more volatile constituents will take place at the high temperatures prevailing during the manufacture of the tube, thus altering the compositions of the various insulating parts and consequently their electrical leakage.

In order to reduce to actual practice the discoveries mentioned above, specific directions are given for the preparation of a refractory composition for the core rods, plugs, and spray coating, to be used in the manufacture of heaters having low electrical leakage while operating as part of a cathode.

Pure beryllium oxide is a light fluffy material which has a melting point around 2500° C., and which cannot be sintered or fritted together when heated at temperatures around 1600° C. for a substantial period; the material remaining practically unaltered in its physical properties after such treatment. On the other hand, beryllium oxide, containing or mixed with definite amounts of other materials of lower melting points, such as silica, magnesium silicate, etc. may be readily sintered or fritted when subjected to temperatures around 1600° C. The amounts of these additive materials necessary to produce a given shrinkage and increase in density varies considerably with the material used. For example, with .1% of silica very little change will be noted. As one of the demands of a satisfactory refractory material is that it shall have sufficient vitrification to produce the desired strength at the temperature used, it is necessary to add a binder to the basic refractory material used. For this purpose I prefer to use silica as it has been found that this material will give the necessary bonding action and at the same time will have no tendency to affect adversely characteristics of the finished tube, such as the electron emission.

In preparing the refractory composition 95% by weight of powdered pure beryllium oxide (alkali-free) is mixed with 5% by weight of pure fused silica, in powder form, and thoroughly mixed together in a dry condition. The powdered material is then packed into a molybdenum boat and heated in a hydrogen furnace for one-half hour at 1600° C. This treatment results in the material sintering and shrinking to about one-fourth its previous volume and increasing in density to about 400%. The sintered material when removed from the boat is in the form of a brick, which is then placed in a porcelain ball-mill with sufficient denatured alcohol for efficient grinding and allowed to mill for fifteen hours, after which it is poured into glass trays and thoroughly dried in a low temperature oven. The ground material is then screened through a 200 mesh screen and bottled for use.

In the manufacture of core rods and end plugs the ground material is mixed with a sufficient quantity of a paste carrier (made of a solution of nitrocellulose) to produce a dough, which is then extruded into rods or plugs by means of a press through a suitable die. The rods or plugs are then baked in air at a temperature of 1600° C.

In the manufacture of the spray coating 100 gms. of the ground material are mixed with 200 ml. of a solution of nitrocellulose in a porcelain ball mill, and the material mixed for two hours, after which it is applied by means of a spray gun to the rotating heater assembly. The assembly is then dried at 100° C., after which it is placed in a molybdenum boat and baked in a hydrogen or vacuum furnace for five minutes at a temperature of 1500° C.

It is obvious from the foregoing that various modifications of my process will suggest themselves to those skilled in the art. As for example, the oxide used and the manner in which the refractory composition is prepared may be varied, as well as the percentage and/or composition of additive materials varied, but I intend to cover all such modifications as come within the scope of the appended claims.

What is claimed is:

1. A heater assembly for an indirectly heated cathode of an electron discharge tube comprising a tungsten wire wound into a helix around a vitrified insulating core rod which consists of 95% beryllium oxide and 5% silica, and a thin vitrified insulating coating adherent to and covering both said wire and said core consisting of 95% beryllium oxide and 5% silica.

2. A heater assembly for an indirectly heated cathode of an electron discharge tube comprising a coil of tungsten wire supported on a vitrified insulating core rod consisting predominately of substantially pure beryllium oxide and approximately 5% of silicon dioxide, and a thin vitrified insulating coating covering both said

wire and core and of the same composition as the core rod.

3. A cathode-heater assembly for an electron discharge tube comprising a tubular cathode sleeve surrounding an electrically insulated heater assembly, said heater assembly consisting of a non-inductive helical coil of tungsten wire wound upon an insulating core rod made of approximately 95% beryllium oxide and approximately 5% silicon dioxide, and a thin adherent vitrified coating covering and adherent to both said tungsten wire and core and consisting of beryllium oxide and silicon dioxide in the same proportions as are present in the core rod.

4. A fine powder for electrically insulating the heater element from the cathode sleeve of an indirectly heated cathode composed of fine particles of a sintered mixture of approximately 95% substantially pure beryllium oxide and approximately 5% silicon dioxide.

5. The method of preparing electrically insulating material for the heater element of an electron discharge tube which comprises mixing approximately 95% by weight of chemically pure fluffy beryllium oxide with approximately 5% by weight of finely powdered dry silicon dioxide, heating said mixture in a hydrogen atmosphere at about 1600° C. until it sinters into a compact coherent mass having a density about four-fold that of the fluffy beryllium oxide, grinding said sintered mass in denatured alcohol to a fine powder, drying said powder at approximately 100° C., screening said dried powder, and mixing said screened powder with a viscous liquid binder to make a suspension suitable for spraying or extrusion.

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